DOCUMENT RESUME

ED 253 391 SE 045 328

AUTHOR	Friend, Harold
TITLE	"The Effect of Science and Mathematics Integration On Selected Seventh Grade Students' Attitudes Toward and Achievement in Science."
INSTITUTION	New York City Board of Education, N.Y.
PUB DATE	[84]
NOTE	17p.
PUB TYPE	Reports - Research/Technical (143)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	*Academic Achievement; Attitude Change; Grade 7; *Integrated Curriculum; Interdisciplinary Approach; Junior High Schools; *Mathematics; Mathematics Education; *Physics; Science Education; Secondary School Mathematics; *Secondary School Science; *Student Attitudes
IDENTIFIERS	Science Education Research

ABSTRACT

The purpose of this study was to determine how integrating science and mathematics in a seventh grade physics unit affected students' attitudes toward and achievement in science. Students were placed in one of four classes. Two classes consisted of students with standardized reading and mathematics scores at least 2 years above grade level; one class (N=30) used the integrated format while the other class (N=27) used the non-integrated format. The two additional classes consisted of students with standardized reading and mathematics scores on grade level; one class (N=24) used the integrated format while the other class (N=27) used the non-integrated format. Results, obtained from pre-/posttests (using the 60-item, Likert-type Science Attitudes Appraisal and the 50-item, teacher-constructed Test of Physics Facts and Principles), show: (1) no change in attitudes toward science among students using either the integrated or non-integrated formats; (2) students 2 years above grade level using the integrated format achieved better than similar students using the non-integrated format; and (3) on-grade level students using the integrated format achieved better than similar students using the non-integrated format. Explanations for these and other results are noted. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED253391

"The Effect of Science and Mathematics Integration On Selected Seventh Grade Students' Attitudes Toward and Achievement in Science."

Harold Friend
New York City Board of Education
Consultant-Science Teacher
143-30 Roosevelt Avenue
Flushing, New York 11354

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Harold Friend
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Many educators believe that integrating the teaching of science and mathematics produces superior learning outcomes than two separately conducted sequences.[1] Science and mathematics should not be separated from or presented as being unrelated to each other. If teachers view the two subjects as being distinct entities that have little to do with one another, students will remain with the idea of separateness in knowledge and subjects as isolated.[2]

Most students have never learned, by experience, that there is a relationship between the world of science and the operations of mathematics. They have little command of fundamental concepts in science and mathematics. Students who have studied the Copernican Revolution often cannot visualize how the sun, moon, planets and stars move in the sky. They learn theories, but have little idea of what phenomena such theories attempt to explain.

A similar situation exists in mathematics. Students have difficulty ordering fractions according to size, determining how many 1/8's of an inch there are in 1 inch, or understanding the decimal number system. They fail to comprehend the relationships between arithmetic operations and verbally expressed questions. Students can multiply numbers, but often cannot answer, "How much money will you receive if you sell 15 dresses at $20 each?" Perhaps if science and mathematics are integrated, students will demonstrate increased cognitive development.[3]

Description, prediction, control and explanation of natural phenomena are among the goals of scientific research. There are many science experiences in which students find it genuinely useful

to employ mathematical processes to help them describe and explain natural phenomena. Science is a place for students to apply mathematical skills. Students will be more willing to investigate science problems if they have the necessary mathematical skills. They will have a more positive attitude toward science and be more likely to demonstrate a higher achievement level.[4]

Lawson and Bealer give additional support for the integration of science and mathematics. They state that programs which attempt to increase scientific and mathematical literacy by utilizing the phenomena of sciences to allow the analyses of mathematics and the application to everyday life may be essential. One proposal to solve the problem of scientific and mathematical literacy in this country is to reverse the trend of relaxing science and mathematics course requirements. Although the proposal has merit, Lawson and Bealer discovered that more is needed to solve the problem. They believe that requiring students who have failed to acquire the ability to apply the most basic quantitative reasoning skills of proportions, probability, and correlations to embark on studies in courses such as calculus, chemistry, and physics, as presently taught, would, for many, lead only to frustration and failure. What is needed is a careful analysis and restructuring of present science and mathematics programs.[5]

Shann reports that teachers and administrators in the Unified Science and Mathematics for Elementary School (USMES) program favored an integrated approach to the teaching of science and mathematics after they had taught the program. Students taught by

the USMES program did not fall behind control group students in learning basic skills. Cognitive development of students was equal, regardless of group (USMES or control). However, USMES students tended to express greater appreciation for science than did control group students. It is believed that students' engagement in some of the activities of scientists may enhance their attitudes toward and interest in science.[6]

Despite agreement by many educators that integrating science and mathematics would be advantageous to teachers and students, one must ask which outcomes would be affected by such an approach. The purpose of the present investigation was to determine how integrating science and mathematics in a seventh grade physics unit affected selected seventh grade students' attitudes toward and achievement in science.

The investigation was limited to science attitudes and achievement. The New York City Board of Education states that science today is best approach through a "unified" approach. All the sciences and necessary mathematics should be melded in an attempt to understand science problems.[7] Mathematical processes help students describe and explain natural phenomena. Science is a place for students to apply mathematical skills.[4] It was from this vantage point that the investigation was designed.

Sample and Methodology

The students involved in the study were 108 New York City seventh graders, divided into 4 classes. Two classes consisted of students with standardized reading and mathematics scores at least 2 years

above grade level, while 2 classes consisted of students with standardized reading and mathematics scores on grade level. All students came from Queens, New York City. Some walked to school, while others used public transportation. They were of a middle socio-economic background. The sample was about one-half male, and one-half female.

The Science Attitudes Appraisal was administered to the sample in April, 1983. The Appraisal is composed of 60 items, divided into 4 sections. The first section appraises the Adoption of Scientific Attitudes (30 items and a maximum score of 150). The second section appraises Attitude Toward Science (10 items and a maximum score of 50). The third section appraises Attitude Toward Scientists (10 items and a maximum score of 50). The final section appraises students' Enjoyment of Science Learning Experiences (10 items and a maximum score of 50). The optimum score is 300 on the Likert-type scale. Each section's items have reverse polarity.

The Appraisal's validity was established by having it evaluated and analyzed by a panel of five science educators, including science department chairpersons and university professors. The instrument was revised after the assessment, incorporating the panel's recommendations. The entire Appraisal has a reliability (Coefficient Alpha) of 0.87.

A teacher-constructed Test of Physics Facts and Principles (New York City Board of Education) was administered to the sample in June, 1983. The achievement test stresses the concepts and problems taught in the physics unit, and consists of 50 objective-type items,

divided into 30 multiple choice items, 10 fill-in-the-blanks items, and 10 modified true-false items.

The instrument's validity was established by having it evaluated by a panel of five science educators, which was composed of a science chairperson and four experienced science teachers (at least 15 years of teaching). The test has a reliability (Kuder-Richardson 21) of 0.85.

The New York City seventh grade physics unit is divided into the areas of "Electricity," "Magnetism," and "Heat." The recommended time allotment is 10 weeks. There are mathematical concepts and problems in each of the science areas, but no attempt is made to integrate the scientific facts and principles with related and necessary mathematical concepts.

A description of the mathematical operations included in each area of the physics unit was produced by the investigator (Table I). The students were required to explain and apply direct and inverse variation when they studied Ohm's Law. Determining area and volume was necessary when discussing and explaining a wire's resistance. Science and mathematics teachers were given both the physics curriculum guide and the list of mathematical concepts and operations. The students were facile in the latter <u>before</u> they were required in science. The mathematics teachers chose problems relevant to the science concepts.

One class (n = 30) with students' standardized reading and mathematics scores at least <u>2 years above</u> grade level, and one class (n = 24) with students' standardized reading and mathematics scores <u>on</u> grade level, followed the science and mathematics integration

Table 1

Mathematical Operations Included in the Seventh Grade Physics Unit

Electricity

Variation
1. Direct
2. Inverse
3. Inverse square

Terminology
1. Base
2. Coefficient
3. Exponent
4. Square
5. Square root

Cylinder
1. Area
2. Volume

Creating Scales
1. Galvanometer
2. Ammeter
3. Voltmeter

Graphs
1. Construction
2. Interpretation
3. Organize data
4. Interpret data

Distance Problems
1. Rate x Time = Distance

Ratio and Proportion
1. Law of Proportions
2. Applications

Magnetism

Variation
1. Direct
2. Inverse
3. Inverse square

Circle
1. Diameter
2. Radius
3. Circumference
4. Area

Graphs
1. Construction
2. Interpretation
3. Organize data
4. Interpret data

Ratio and Proportion
1. Law of Proportions
2. Applications

Scientific Notation
1. Multiplication
2. Division

Heat

Thermometers
1. Design
2. Calibration
3. Precision
4. Accuracy
5. Signed numbers
6. Absolute value
7. Range

Graphs
1. Construction
2. Interpretation
3. Organize data
4. Interpret data

Heat Problems
1. Calories
2. Temperature Change
3. Heat of fusion
4. Heat of vapor
5. Order of operations

format. The investigator taught both classes science. The two classes were taught mathematics by two different teachers, both of whom had similar professional backgrounds and experience.

One class (n = 27) with students' standardized reading and mathematics scores at least 2 years above grade level, and one class (n = 27) with students' standardized reading and mathematics scores on grade level, followed the non-integrated science and mathematics format. Both classes were taught by the same teachers as the classes that followed the integrated format.

The investigation lasted 10 weeks. Students' attitudes toward science and knowledge of specific physics facts and principles were assessed again, using The Science Attitudes Appraisal and the Test of Physics Facts and Principles.

Findings

The results of correlated t-tests, comparing The Science Attitudes Appraisal scores before and after science and mathematics integration are provided in Table 2.

Integrating science and mathematics did not result in a more positive attitude toward science for students with standardized reading and mathematics scores at least 2 years above grade level. This was the result for the entire Appraisal as well as for each of its 4 sections. Careful examination of the scores indicates that scores on 3 Appraisal sections (Attitude Toward Science, Attitude Toward Scientists, and Enjoyment of Science Learning Experiences) actually decreased slightly, as did the total Appraisal score. The decrease was not significant.

Table 2

The Science Attitudes Appraisal Scores
Before and After Science and Mathematics Integration

Class	Appraisal Section	Pre-test Mean	Post-test Mean	t
Integrated: Above Grade (n = 30)	Scientific Attitudes	111.00	111.23	0.22
	Attitude Toward Science	40.43	39.23	1.51
	Attitude Toward Scientists	32.77	31.50	1.63
	Enjoyment of Science	39.63	38.30	1.29
	Totals	223.63	221.90	0.67
Integrated: On Grade (n = 24)	Scientific Attitudes	99.71	106.38	3.96*
	Attitude Toward Science	37.58	37.63	0.04
	Attitude Toward Scientists	32.38	31.54	1.23
	Enjoyment of Science	37.54	38.33	0.68
	Totals	209.96	213.08	1.96
Non-Integrated: Above Grade (n = 27)	Scientific Attitudes	106.67	107.41	0.57
	Attitude Toward Science	37.78	38.52	0.79
	Attitude Toward Scientists	32.74	33.78	1.32
	Enjoyment of Science	36.30	37.67	1.17
	Totals	213.48	217.15	1.56
Non-Integrated: On Grade (n = 27)	Scientific Attitudes	100.00	101.85	1.09
	Attitude Toward Science	35.7[illegible]	34.44	1.07
	Attitude Toward Scientists	33.5[illegible]	33.00	0.50
	Enjoyment of Science	36.2[illegible]	34.22	1.61
	Totals	205.4[illegible]	203.04	0.71

*Significant at .0[illegible] level

Students taught by the non-integrated format did not score any significant increase on the total Appraisal, or on any of its 4 sections. This occurred whether the students' standardized reading and mathematics scores were at least 2 years above grade level, or were on grade level. The latter students had scores that decreased in 3 Appraisal sections (Attitude Toward Science, Attitude Toward Scientists, and Enjoyment of Science Learning Experiences) as well as on the total Appraisal. The decrease was not significant.

Table 3 shows the results of analysis of variance, comparing achievement in science of students who had science and mathematics integrated, with achievement in science of students who were taught using the non-integrated format. The analysis of variance scores indicate that students with standardized reading and mathematics scores at least 2 years above grade level who had science and mathematics integrated showed significantly greater achievement (.01 level) in science on the Test of Physics Facts and Principles than similar students who were taught by the non-integrated format. However, there was no difference in science achievement on the Test of Physics Facts and Principles of students with standardized reading and mathematics scores on grade level, whether or not there was science and mathematics integration.

An interesting comparison is between students with standardized reading and mathematics scores at least 2 years above grade level who were taught using the non-integrated format and students with standardized reading and mathematics scores on grade level who had science and mathematics integrated. Analysis of variance scores (Table 4) indicate that above grade level students taught by the non-integrated format

Table 3

Analysis of Variance for the Test of Physics Facts and Principles Comparing Students Taught by Science and Mathematics Integration to Students Taught Using the Non-Integrated Format

		SS	d.f.	M.S.	F
Students Above Grade Level:					
	Between	271.4	1	271.4	48.5*
	Within	310.3	55	5.6	
	Totals	581.7			
Students On Grade Level					
	Between	45.3	1	45.3	1.7
	Within	1302.7	49	26.6	
	Totals	1348.0			

*Significant at .01 level.

Table 4

Analysis of Variance for the Test of Physics Facts and Principles Comparing Above Grade Level Students Taught by the Non-Integrated Format to On Grade Level Students Taught by the Integrated Format

	SS	d.f.	M.S.	F
Between	167.4	1	167.4	11.4*
Within	720.3	49	14.7	
Totals	887.7			

*Significant at .01 level.

demonstrated significantly greater achievement (.01 level) in science on the Test of Physics Facts and Principles than on grade level students who had science and mathematics integrated.

Discussion

Students with standardized reading and mathematics scores at least 2 years above grade level who had science and mathematics integrated did not develop more positive attitudes in any Appraisal section, or on the Appraisal as an entity. This does not support Rowe's contention that students will have a more positive attitude toward science if they have the necessary mathematical skills, nor does it confirm Shann's belief that students taught using an integrated approach to science and mathematics will tend to express greater appreciation for science.[4,6]

It must be recognized that these students had above grade level abilities in reading and mathematics, and an initially high score (223.33 of a possible 300.00) on The Science Attitudes Appraisal. There wasn't much room for improvement, since the students already had fairly positive attitudes toward science. The investigation commenced in April. It is possible that students' attitudes changed during the first 7 months of the year, thus lessening any impact science and mathematics integration might have produced.

An exception to the initially high scores were the results on the Attitudes Toward Scientists section. Students' initial scores were low (32.77 of a possible 50.00), as were their final scores (31.50 of a possible 50.00) Eliminating this result further emphaiszes the high initial scores. Equally important is the contention that the reason the students' Attitudes Toward Scientists scores were so low is that seventh

graders do not have much, if any, contact with scientists. Since there is little first-hand knowledge of scientists as people, many negative beliefs result. This premise was presented by a number of distinguished science educators, discussing The Science Attitudes Appraisal at the 1983 National Association for Research in Science Teaching convention.

Students with standardized reading and mathematics scores on grade level who had science and mathematics integrated did not develop a more positive attitude on The Science Attitudes Appraisal as an entity, but did produce a significant increase in Scientific Attitudes (.01 level). Such students' initial scores on the Scientific Attitudes section were fairly low (99.71 of a possible 150.00), but increased after science and mathematics integration to 106.33. There was room for improvement, and the improvement occurred. It is possible that the integration of the disciplines provided the students with an impetus, and the students reacted by developing a more positive scientific attitude.

This partially supports Rowe and Shann, but one must emphasize that the students were on grade level in reading and mathematics. Further research is needed to clarify and establish what relationships, if any, exist between science and mathematics integration and student ability.

On the Attitude Toward Scientists section, the on grade level students had extremely low initial scores (32.38 of a possible 50.00). This supports the contention that a lack of contact with or exposure to scientists results in a lack of positive attitudes toward scientists.

Students with standardized reading and mathematics scores at least 2 years above grade level who had science and mathematics integrated scored significantly higher results (.01 level) on the Test of Physics

Facts and Principles than similar students who did not follow the integrated format. Perhaps integrating the disciplines allowed the students to develop insights into physics that a non-integrated format did not. This supports the claim that if science and mathematics are integrated, students will demonstrate increased cognitive development.[3]

Students with standardized reading and mathematics scores on grade level who had science and mathematics integrated did not produce significantly greater scores on the Test of Physics Facts and Principles than students who did not have the disciplines integrated. One reason might be that such students' reading and mathematics abilities were not great enough to allow them to develop the insights into physics that their counterparts in the high-ability group developed when science and mathematics were integrated.

Lastly, students with standardized reading and mathematics scores at least 2 years above grade level who were taught by the non-integrated format demonstrated significantly greater achievement in science (.01 level) on the Test of Physics Facts and Principles than on grade students who had science and mathematics integrated. This is explained by the fact that reading skills are closely associated with the important processes of science. Better reading produces better science learning.[4]

References

1. Kren, Sandra R., and John P. Huntsberger. Should Science be Used to Teach Mathematical Skills? Journal of Research in Science Teaching, 1977, 14(6), 557-561.

2. Carter, Martha A. A View From the Top: Elementary Science and the Three R's. The American Biology Teacher, 1978, 40, 146-147.

3. Kolodiy, George O. A Piaget-Based Integrated Math and Science Program. Journal of College Teaching, 1984, XIII(4), 397-399.

4. Rowe, Mary Budd. Teaching Science as Continuous Inquiry. New York: McGraw-Hill Book Company, 1973.

5. Lawson, Anton E., and Jonathan M. Bealer. The Acquisition of Basic Quantitative Reasoning Skills During Adolescence: Learning or Development? Journal of Research in Science Teaching, 1984, 21(4), 417-423.

6. Shann, Mary H. Evaluation of an Interdisciplinary, Problem-Solving Curriculum in Elementary Science and Mathematics. Science Education, 1977, 61(4), 491-502.

7. General Science. Brooklyn, New York: New York City Board of Education, 1983.